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Discussion paper [or working paper, etc.]

Original citation:
Bijapur, Mohan, Croci, Manuela and Zaidi, Rida (2012) Do asset regulations impede portfolio diversification? evidence from European life insurance funds. Social Science Electronic Publishing, Inc., New York, USA.

Originally available from Social Science Research Network

This version available at: http://eprints.lse.ac.uk/56618/
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Do Asset Regulations Impede Portfolio Diversification? Evidence from European Life Insurance Funds

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Abstract

We investigate the effects of regulatory restrictions on the amounts invested in risky asset classes in life insurance funds across EU countries. By estimating a panel data econometric model, we find that these restrictions have an economically and statistically significant negative impact on risk-adjusted returns of approximately 1-2 percentage points, holding constant other relevant factors. The use of explicit limits on asset allocation can be a blunt instrument for regulating risk-taking, in that they impede investment managers' ability to exploit the benefits of portfolio diversification, and thus distort portfolio selection below the efficient frontier. We also find that those countries which impose the most stringent constraints tend to experience the largest efficiency losses. Furthermore, our results suggest that firms subject to prescriptive regulation are less able to respond quickly under conditions of financial market turbulence. Our results are robust to inclusion of additional controls, tests for fixed effects and country-specific heterogeneity, and other robustness checks.

Keywords: Financial regulation; asset allocation; portfolio risk diversification; life insurance funds.
JEL classification: G11, G22, G28.

1. Introduction

In this paper, we investigate the effects of regulatory requirements which restrict the amount invested in risky asset classes in life insurance investment portfolios. The recent global financial crisis has highlighted the importance of financial regulation, with many commentators arguing that the combined effects of excessive risk-taking by financial institutions and a "light touch" approach to regulation contributed significantly to the crisis (see, for example, the US Financial Crisis Inquiry Report, 2011), resulting in severe and long-lasting effects on the real economy (Bijapur, 2010, 2012). Although the potential benefits of constraining investment in risky assets have received much attention in the policy debate, the motivation for our paper is to investigate the potential costs. We undertake a panel data

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econometric analysis of returns on life insurance funds across seven European countries. Comparing countries which impose caps on risky asset class investments with those which do not, we find evidence of a significant efficiency loss and estimate that these restrictions have an economically and statistically significant negative impact on risk-adjusted returns, controlling for other relevant factors.

The intuition behind our results is grounded in the well-known principles of Markowitz (1952) portfolio theory. In unconstrained portfolio choice, investment managers choose portfolios of assets which maximize expected return for a target level of risk, i.e. those which lie on the efficient frontier. The imposition of regulations which constrain the amount investable in certain risky asset classes may prevent managers from constructing optimal portfolios and fully exploiting the benefits of diversification which arise through weak or negative correlations between different asset classes. This can distort portfolio choice below the efficient frontier.[1] For example, regulators might impose a cap on the proportion invested in equities or, alternatively, a floor on the proportion invested in government bonds, with the objective of limiting the riskiness of asset portfolios. However, this approach fails to take advantage of the weak historical correlation between equities and bonds (see, for example, Brown and Reilly, 2012), such that a balanced portfolio combining both asset classes would enable a reduction in overall portfolio risk whilst achieving equivalent or higher returns. Put differently, firms subject to regulatory limits would achieve lower expected returns, holding constant the level of risk. In a similar vein, a ban on investment in foreign currency assets with a view to minimizing exchange rate risk might be counter-productive, as it prevents managers from exploiting the more than offsetting benefits of international diversification which arise due to imperfect correlations between different countries' securities markets (Reilly and Wright, 2004).

The focus of this paper is on the effects of regulation on the performance of life insurance investment funds. The reason for this choice of market is that there exists explicit heterogeneity in the type of regulation applied across EU countries, which makes for an interesting natural experiment on the effects of asset allocation restrictions on portfolio efficiency. More specifically, the system of regulation applied to portfolios of assets covering

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[1] Even in countries which do not impose restrictions on asset allocation, investment managers' portfolio choices will generally be subject to a series of other constraints (liquidity needs, time horizon, tax concerns, unique preferences (Brown and Reilly, 2012). However, the objective of our paper is to test whether the effects of regulatory constraints decrease portfolio efficiency, holding constant all other constraints.

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insurance firms' liabilities across EU member states consists of two distinct approaches: Quantitative Restrictions (QR) and the Prudent Person Rule (PPR)[2]. QR aims to limit portfolio risk by imposing explicit caps on the proportion of total funds that an insurance firm is permitted to invest in specific risky asset classes (for example, an upper limit of 30 per cent in equities, or 10 per cent in foreign currency assets, or an outright ban on investment in derivatives). In contrast, the PPR regime entails quite a different approach to regulation, it does not impose explicit restrictions on asset allocation, but merely requires that managers invest "prudently" and follow broad principles of portfolio diversification and asset-liability matching. In practice, this is enforced not through explicit monitoring of portfolio composition, but through ensuring that the appropriate internal controls and governance structures are in place[3].

We build on Davis (2001), who undertakes a cross-country comparison of aggregate returns in PPR and QR countries, extending his work in three key respects. First, whereas Davis uses macroeconomic data (weighting the relevant security market indices by the aggregate proportions invested in each asset class in each country), we use actual fund returns from a sample of 373 life insurance firms. Second, we adjust for risk by estimating Sharpe ratios for each fund. This is necessary in order to distinguish whether higher returns in PPR countries are driven by a preference for greater risk-taking relative to QR countries, i.e. movements *along* the efficient frontier, or reflect the inability of QR countries to manage risk effectively by fully exploiting the benefits of portfolio diversification, thus forcing them *below* the efficient frontier.

Third, we estimate a panel data econometric model which controls for sources of heterogeneity in fund returns other than the impact of regulation, including firm size, country-specific market returns and volatilities, and the possibility of unobserved firm-

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[2] Regulation of the insurance industry is required due to the existence of two types of market failure, first, the presence of asymmetric information between insurance firms and consumers, and second, the existence of externalities from insolvency of insurance firms, which can be quite considerable (as highlighted by the US government 2008 bailout of the insurance conglomerate AIG). Insurance firms across EU member states are currently subject to the Solvency I regime of prudential regulation, which stipulates capital requirements in order to reduce the risk of insurer insolvency and thereby protect policyholders and support market stability. In addition to this, most countries supplement solvency capital requirements by regulating the portfolio of assets covering firms' liabilities.

[3] The EU Solvency I regime also imposes concentration limits on insurance firms, i.e. limits on the proportion of total funds which can be invested in any individual security. However, these requirements are applied uniformly across Member States, hence we do not focus on these rules, given that the lack of heterogeneity makes it impossible to isolate their effects on fund performance.

specific or country-specific heterogeneity. Finally, we conduct a series of robustness checks, including additional controls and testing for structural breaks and survivorship bias, and find that the broad flavor of our results continues to hold.

Some other relevant papers in the existing literature are discussed here. Del Guercio (1996) presents evidence that the "Prudent-Man" regulation of US pension funds distorts portfolio choice towards high quality "prudent" stocks. However, whereas she focuses on individual stock selection, our concern is with asset allocation. Chen et al. (2007) find that insurance company mutual funds tend to underperform non-insurance mutual funds, but attribute this not to the effects of regulation, but rather to aggravation of agency problems. Cheng et al. (2011) investigate the impact of the Prudent-Man rule on the relationship between risk taking of life-health insurers and stability of their institutional owners. Davis (1988) investigates the effects of portfolio regulations in impeding portfolio adjustment to short-term market conditions. However, his focus is on "tactical asset allocation", whereas our main focus is on the relationship between asset allocation and portfolio diversification. Baranoff and Sager (2009) also investigate asset allocation of life insurers, but their focus is on the effects of active vs. passive management strategies on investment performance, as opposed to the specific impacts of regulation which we look at. Danielsson et al. (2004) show that risk regulation can have other unintended consequences, different to those which we explore, due to feedback effects which exacerbate short-term asset price volatility. Several other papers focus on the effects of capital regulation on insolvency risk in insurance firms (Butsic, 1994; Pasiouras and Gaganis, 2009; Shim, 2010), as opposed to the rules on asset allocation which we focus on.

The structure of the paper is organized as follows. In Section 2, we describe data issues and present descriptive statistics. In Section 3, we discuss our risk-adjustment techniques, present the panel data econometric model and discuss our choice of estimation methods. In Section 4, we present and discuss our results. In Section 5, we summarize our conclusions and discuss policy implications.

2. Data issues

Our sample consists of seven European Union countries, five of which use QR regulation, whilst the remaining two adopt the PPR approach (this information is based on Davis (2001)). The restrictions mostly apply to limits on equities, real estate and foreign assets. All countries (including PPR regimes) also specify limits on self-investment. We give details of the limits on equity investment in each country in Table 1 below. Our sample of countries is limited due to lack of data availability. Although it would be desirable to have a larger sample in order to isolate the effects of regulation with greater precision, the advantage of our smaller selection of countries is that they are fairly homogeneous in many respects other than the type of portfolio regulation in place, thus facilitating our task of controlling for country-specific effects which might affect investment returns and are potentially correlated with the regulation variable. For instance, portfolio regulation is only one aspect of regulation which affects the insurance industry, however, this is less of a concern for us given that all countries in our sample are bound by the same EU minimum requirements on solvency regulation. Furthermore, there exists a degree of harmonization in tax regimes across the EU, which mitigates the problem of controlling for variation in investment returns due to differential tax treatments.

All firm-level data is taken from Standard & Poor's Eurothesys database, which provides financial statements data for life insurance firms across OECD countries, denominated in euros. Our estimation sample consists of annual data from 1996-2004, and is an unbalanced panel, with many firms missing observations for the earlier or later part of the time series (due to entry and exit of firms, and mergers and acquisitions). In total, we include 373 firms, with reasonable coverage across all countries, although the UK and Germany have a larger coverage of firms than other countries. The sample includes both public companies and mutuals, although there is no bias towards either type of organization in QR or PPR countries. For consistency, we use book values of assets in constructing the investment portfolios, as market values were unavailable for a large proportion of the sample.

The dataset required extensive data-cleaning, the main reason for this being that many firms do not report information on all asset categories. The full set of asset classes reported includes equities, bonds, real estate, loans, cash/bank deposits and derivatives. Data on derivatives is very patchy, so we exclude this asset class entirely. Given that equities and bonds are the major investment categories, we exclude any firms which omit information on either of these. However, firms not reporting real estate holdings are retained, given that it is plausible that many firms will not invest in this asset class (smaller firms in particular who do not benefit from economies of scale in real estate investment)[4]. We further exclude any observation for which the sum of reported investments in the disaggregated asset class data accounts for less than 60 per cent, or exceeds 105 per cent, of total investment. A further problem is that for many German firms, reported investments in bonds are unusually low. We believe this is due to the widespread investment by German firms in debt-like instruments which are not explicitly counted as debt, such as pfandbriefe (a type of covered bond) and other mortgage-backed securities. Hence, to correct for this, for any German firm which is missing more than 40 per cent of total investment, we attribute these missing assets to pfandbriefe etc. and include these in the bonds category. We feel this is a reasonable adjustment to make, as failure to do so leads to an implausibly high weighting in equities for German firms of almost 50 per cent. A series of robustness checks confirms that these data-cleaning measures do not bias the results (see section 4.4 below)[5]. Post-cleaning, the sample includes 2067 observations in total[6], which we deem sufficient to obtain an adequate degree of estimation efficiency.

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[4] We also retain firms which do not report information on loans or cash, as these are considered minor investment categories.

[5] It is also worth noting that the problem of missing investment categories only affects our estimates of portfolio risk, for which we require the disaggregated asset class data, whereas portfolio returns data are unaffected as these are based on the aggregate investment income/capital gains data which is reported for the entire portfolio of assets (see section 3.2 below).

[6] Further data cleaning was required to exclude some observations which misreport units of measurement, and elimination of large outliers in the returns and risks data. In total, approximately 40 per cent of observations were lost through data-cleaning.

Country	Number of firms	Regulatory regime	Limit on equities (per cent)	Actual equity holdings[a] (per cent)	Investment returns (percentage points)	Portfolio risk (percentage points)
Finland	19	QR	50	17.3	10.2	9.9
France	50	QR	65	13.4	9.7	4.8
Germany	134	QR	30	21.1	7.4	6.5
Italy	39	QR	20	6.0	8.1	4.7
Netherlands	22	PPR	none	15.4	8.8	6.4
Sweden	19	QR	25	36.3	10.0	10.7
UK	90	PPR	none	35.5	10.7	6.3
QR countries[b]	261	n/a	n/a	18.6	8.2	6.5
PPR countries[b]	112	n/a	n/a	31.5	10.3	6.3
Total[b]	373	n/a	n/a	21.8	8.7	6.5

[a] Percentage of total investments. [b] Unweighted average across all firms.

Table 1: Descriptive statistics

We note three points of interest from a preliminary examination of the data. First, average portfolio weights in equity investments are significantly higher in PPR countries compared to QR countries. This seems, in part, to be driven by the tight constraints imposed in some countries, in particular Germany, who is investing close to her limit[7]. Second, average nominal investment returns are approximately 2 percentage points higher in PPR countries, which is consistent with the higher weighting in equities in these countries. Third, their superior investment performance does not seem to be driven entirely by more aggressive risk-

[7] It may seem puzzling that Swedish firms actually breach, on average, their QR limit on equity holdings, but this is due to the fact that the rules are applied only to assets covering an insurance firm's technical provisions (i.e. liabilities to policyholders). Any "free capital" is not bound by legal constraints and can be invested howsoever the firm may wish.

taking, as average risk levels are quite similar across PPR and QR regimes. Thus, tentatively, the data is supportive of the view that QR countries are holding (relatively) inefficient portfolios. Even though PPR countries are investing more heavily in equities and generating higher returns, due to the flexibility afforded by their regulatory regimes, they seem more able to manage portfolio risk.

3. Model specification and estimation methods

3.1 Risk Adjustment

The standard technique for adjusting returns for risk used widely in the literature is to run (multi-factor) Jensen regressions. However, it is not possible to use this approach, due to the short length of our time series data (each fund contains only nine annual returns at most). Instead, we adjust for risk by estimating Sharpe ratios[8] for each fund. Although this is a cruder technique of risk-adjustment (in particular because it does not disaggregate between systematic (non-diversifiable) risk and idiosyncratic (diversifiable) risk), Sharpe ratios are widely used under conditions of limited data availability (Sharpe, 1994).

Recall that our key objective is to test whether portfolios are less efficient in QR countries relative to PPR countries. We show that this is equivalent to testing whether portfolio Sharpe ratios are on average lower in QR countries than in PPR countries with reference to Figure 1 below. Following CAPM, the unconstrained investment manager in the PPR country[9] optimizes by choosing the tangency portfolio of risky assets located at point PPR (assume for simplicity net cash holdings are zero). Suppose the manager in the QR country has a risk target of σ_1, this could be achieved through an efficient portfolio consisting of the same mix of risky assets as in the tangency portfolio and an appropriate weight in cash so that she moves down the capital market line (CML) to point A. However, the QR country imposes a limit on equity investment so that this point cannot be attained and instead the manager must choose portfolio QR, which is below the efficient frontier/CML. Note that:

$$(QR\text{-}RFR)/\ \sigma_1 < (A\text{-}RFR)/\ \sigma_1 = (PPR\text{-}RFR)/\ \sigma_2$$

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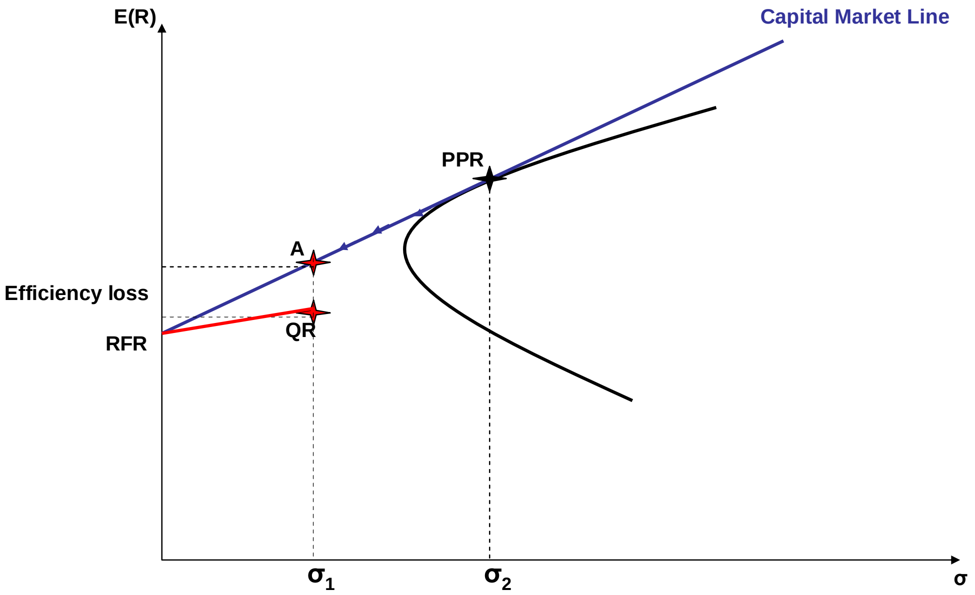
[8] The Sharpe ratio is defined as excess return (expected return minus the risk-free rate) divided by standard deviation of returns.

[9] This result continues to hold if the PPR manager also locates below the efficient frontier.

and thus the QR portfolio has a lower Sharpe ratio than the PPR portfolio. It is easily shown that the converse also holds, i.e. a lower Sharpe ratio implies a less efficient portfolio.



E(R) denotes expected return; σ denotes standard deviation; RFR denotes risk-free rate.

Figure 1: Sharpe ratios and portfolio efficiency

3.2 Model specification

Our model specification is:

$$\frac{r_{ijt} - r_{jt}^{f}}{\sigma_{ijt}} = \alpha + \eta_i + \gamma\, size_{ijt} + (\beta + v_j)\, mktrets_{jt} + \lambda QR_j + \varepsilon_{ijt}$$

where r_{ijt} denotes nominal investment returns for firm *i* in country *j* on date *t*, r_{jt}^{f} denotes the risk-free interest rate, σ_{ijt} denotes portfolio risk, $size_{ijt}$ denotes fund size, $mktrets_{jt}$ denotes market returns (adjusted for volatility), and QR_j denotes a regulation dummy. η_i and v_j denote random effects for firm *i* and country *j* respectively (included in some specifications).

The dependent variable is specified as the per-period Sharpe ratio. Portfolio returns (r_{ijt}) (defined as post-tax nominal returns, gross of management expenses) are constructed from the constituent balance sheet items using the following formula[10]:

return = (investment income + net capital gains)/total investment

It is not possible to estimate portfolio risk by computing the standard deviation of actual returns in each fund, given the short length of time series data. Instead, we compute the standard deviations and correlations of historical returns on the market indices for equities, bonds and real estate[11] (cash is assumed to have zero variance and covariance) for each country, and estimate the individual portfolio risks by taking a weighted average of the market-wide standard deviations, using the standard formula:

$$\sigma_{ijt} = \sqrt{\left(\sum_{x \subseteq \{E,B,P\}} \alpha_{xijt}^{2} \sigma_{xj}^{2} + \sum_{\forall x \neq y} 2\alpha_{xijt} \alpha_{yijt} \sigma_{xyj} \right)}$$

where E denotes equities, B denotes bonds/loans, P denotes real estate, and α_x denotes the portfolio weight for asset class x. For the risk-free interest rate, we use the three-month LIBOR rate[12]. All interest rate data is taken from DataStream.

Regulation variable

We construct two alternative variables to measure the impact of regulation. The first is a simple binary dummy which takes value 0 for PPR countries and 1 for QR countries. However, given that there is significant heterogeneity across countries in the severity of the restrictions applied, we account for this by also specifying a categorical variable in which countries are divided into three groups: PPR, weak QR and strong QR. Strong QR countries are defined as those which impose the tightest limits on equity holdings (less than or equal to 30 per cent), hence this includes Italy, Sweden and Germany (see Table 1). The reason for this classification scheme is that we believe that restrictions on equities and foreign assets impose the greatest constraints on portfolio efficiency, given that they significantly limit the

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[10] For the denominator, we take the average value of total investments in periods t and t-1, given that we are using annual data.
[11] For each country, we use a quarterly time series of market returns over 1980-2006, then annualize the estimates in order to be consistent with the firm-level data.
[12] Ideally, one would use the overnight rate, however, over our estimation period the spread between the three month and overnight rate is narrow and stable.

scope for diversification (see section 1 above for further discussion). But given that restrictions on foreign assets are fairly homogeneous across the QR sample, the designation of weak as opposed to strong QR depends solely on the limit imposed on equities.

Control variables

In order to isolate the effects of regulation and control for other factors which are important determinants of fund performance, we include a number of additional explanatory variables in the regression equation. First, we need to control for cross-country variation in market returns and volatilities. Thus, we include the market returns adjusted for volatility (i.e. the market Sharpe ratios) for the equity, bond and real estate markets for the relevant country, specified as $(R_{jt}^{M} - r_{jt}^{f})/\sigma_{j}$ where R_{jt}^{M} denotes the market return in country *j* on date *t* and σ_{j} denotes the historical market standard deviation. Equity/bond returns are total returns including re-invested dividends/coupons. Due to unavailability of data on real estate prices, real estate returns are proxied using market returns on real estate investment funds. This is a reasonable proxy, given the existence of a strong historical correlation between real estate prices and returns on these funds (although note, as a caveat, that Haß et al. (2012) find that the volatility of listed real estate indices is much higher than that of direct real estate). All market returns data is taken from DataStream[13].

Several empirical studies have also found that fund size can have a significant impact on investment performance, hence we also include a control for this, using log of total investments (lagged one year).

3.3 Hypotheses and estimation methods

We test for evidence that QR regulation leads to lower risk-adjusted returns by testing whether the co-efficient on the regulation dummy variable is negative. Formally, we test the null H_0: $\lambda = 0$ against the (two-tailed) alternative H_1: $\lambda \neq 0$. We use panel data methods in order to test for unobserved firm-specific and country-specific heterogeneity which may be correlated with the regressors (fixed effects) and thus lead to biased estimates. This might occur, for example, if investment styles differ across countries simply due to a cultural

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[13] For the stock market indices, we use OMX Helsinki (Finland), CAC 40 (France), DAX 30 (Germany), MIBTEL (Italy), AEX (Netherlands), OMX Stockholm (Sweden), FTSE 100 (UK). For bond markets we use the JP Morgan Government Bond Indices and for real estate we use the FTSE EPRA/NAREIT Investment Trusts Indices.

aversion to stock market investment, or the existence of home country bias. Fixed effects might also arise at the firm level due to variation in investment management objectives, i.e. profit-maximizing public companies as opposed to mutually-owned companies. We employ the following estimators[14]:

(1) Pooled OLS: all parameters are assumed fixed and homogeneous across all firms and countries.

(2) Random Effects GLS (RE): the intercept term is random, i.e. each firm's intercept is a realization from a probability distribution with fixed mean and variance, and distributed independently of the regressors; all other parameters are fixed and homogeneous.

(3) Between Groups (BG): OLS estimation on the group means.

(4) Hausman-Taylor (H-T): the standard Hausman test for the presence of fixed effects is infeasible, given that the regulation variable is time-invariant. More specifically, it is not possible to include both fixed effects and time invariant regressors, as this results in failure of the full rank condition for the matrix of regressors, i.e. the model is under-identified. Instead, we undertake H-T estimation, which enables testing for fixed effects in the presence of time-invariant regressors (this is a form of two stage least squares, which uses the group means of the time-varying exogenous variables as instruments for the time-invariant endogenous variables).

4. Results

4.1 Main results

The results provide supportive evidence that the constraints on asset allocation prescribed by QR regulation lead to lower risk-adjusted returns. The parameter estimate on the regulation variable displays the predicted negative sign in all panel model specifications and is statistically significant (at the 1 per cent level in pooled OLS and 5 per cent level in RE estimation). We also find that the effects of QR regulation are economically significant, leading to a reduction in excess returns per unit risk of 0.15-0.22, holding constant all other

[14] More sophisticated dynamic panel data models for dealing with endogeneity, such as GMM estimation, were deemed unnecessary as our model specification does not include any lagged dependent variables and hence the problem of small sample bias does not arise.

variables (see Table A1, Appendix A for full estimation results). It is more meaningful to express our estimates in terms of nominal returns. To do this, we assume a risk target of 6.5 percentage points (which is the simply the mean estimated portfolio risk for the whole sample), and using the formula for the Sharpe ratio[15], we estimate QR regulation leads to a reduction in risk-adjusted returns of 1-1.4 percentage points. The higher average investment returns in PPR countries are due to higher weighting in equities. However, by adjusting for risk, our results show that the outperformance of PPR countries is not driven purely by more aggressive risk-taking relative to QR countries, i.e. movement *along* the efficient frontier, it also reflects the inability of QR countries to fully exploit the benefits of portfolio diversification, thus resulting in distortion *below* the efficient frontier.

Our results on the three-tier regulation index suggest that those countries which impose the most stringent constraints tend to experience the largest reduction in risk-adjusted returns. The parameter estimate on the weak QR dummy is no longer statistically significant, whereas the strong QR dummy is highly significant and implies a larger reduction in risk-adjusted returns of 1.5-2.1 percentage points relative to PPR countries. A Wald test on the restriction of homogeneity on the co-efficients on the weak QR and strong QR dummies is firmly rejected at the 1 per cent level. These results suggest that it is not just the overall choice of QR versus PPR regime that matters, the severity of the restrictions applied makes a difference in terms of the efficiency cost in portfolio performance. In weak QR countries (Finland and France), the constraints on equity investment are not binding (see Table 1), and hence there do not appear to be any significant distortionary impacts on investment decisions or portfolio diversification. Note also that despite exhibiting above average returns, French funds have rather low risk levels. Hence, it seems that with her very high ceiling on permitted equity holdings, France seems to adopt a regulatory approach which resembles more closely a PPR than a QR regime. In the remainder of the paper, for brevity, we discuss the estimation results for the binary regulation dummy only.

4.2 Testing for fixed versus random effects

The parameter estimates remain stable across all panel model specifications, retaining the same signs and relatively similar magnitudes. The Breusch-Pagan Lagrange Multiplier test is

[15] We use the same procedure and the same risk target of 6.5 per cent for converting Sharpe ratio estimates into nominal returns throughout the paper.

significant at the 1 per cent level, indicating strong evidence of group effects. In order to test whether these are fixed or random, we conduct Hausman-Taylor estimation. The first stage in the H-T estimation procedure is to estimate fixed effects OLS (dropping the time-invariant regulation variable) and conduct the Hausman test to determine which of the regressors are exogenous and therefore useful as instruments. The results only indicate that the real estate returns variable is endogenous, hence the others are used to instrument the regulation variable. The correlations with the regulation variable are sufficient to avoid a weak instrument problem. H-T imposes an identification condition that the number of exogenous time-varying regressors (size, bond returns and equity returns) must be greater than or equal to the number of endogenous time-invariant regressors (regulation), hence this is satisfied. In the second stage, following Baltagi et al. (2003), we conduct the Hausman test on random effects versus H-T, to detect the presence of fixed effects. Hausman gives a strong rejection of RE in favour of H-T (we reject the null of no fixed effects at the 1 per cent significance level). Although there is strong evidence of fixed effects, the QR parameter estimate actually increases in magnitude and in statistical significance in the H-T estimation. Hence, if anything, the presence of fixed effects may lead us to underestimate the true impact of QR regulation.

In order to investigate further what is causing the fixed effects, following on from the above discussion that France seems to better fit the pattern of a PPR regime, we re-specify the regulation variable to denote France as a PPR country, then repeat the H-T estimation procedure. The results show a marked contrast - the Hausman test is no longer significant at the 10 per cent level, suggesting that the detection of fixed effects is actually reflecting the mis-categorization of France's regulatory approach, rather than a more pernicious problem of omitted variables. Taking these factors into consideration, we choose random effects over fixed effects as our preferred estimator, and hence all results which follow pertain to random effects GLS (unless otherwise indicated).

Diagnostics on residuals

The White test and the Breusch-Pagan/Cook-Weisberg test for heteroscedasticity are both significant at the 1 per cent level. The second test is repeated with respect to each of the right-hand side variables, but it is only significant for log of total investments. This suggests that the presence of heteroscedasticity is caused by variation in firm size, rather than a more serious problem of omitted variables. There also appears to be evidence of serial correlation -

the Wooldridge test for panel autocorrelation is significant at the 1 per cent level. In line with standard practice, all standard errors are corrected by using heteroscedasticity-robust standard errors throughout.

4.3 Control Variables

As we would expect, there is a positive and highly significant relationship between the whole of market (equities, bonds and real estate) returns variables and individual fund performance. Thus, it proves important to control for cross-country variation in market performance. The estimated size co-efficient is negative and economically, but not statistically, significant. This result is consistent with findings in several existing empirical studies, e.g. Blake et al. (2002), who rationalize this as a “size is an anchor to performance” effect, i.e. large investing institutions with a large market share in a given market cannot benefit fully from active trading given that trading induces more easily detectable price movements.

As a robustness check, we extend our somewhat parsimonious model specification to include several other regressors which may potentially be important in explaining investment returns. The inclusion of these additional controls has very little effect on the estimated regulation co-efficient (see Table A2, Appendix A - note that the estimation sample size is smaller due to data unavailability for some of these variables, but in a comparison of the QR parameter estimates with and without the additional controls, based on the same subsample, there is very little difference). We include the firm’s capital ratio (defined as share capital divided by total assets) as an additional regressor, but this is not statistically significant. Given that there may be a problem of endogeneity, i.e. firms investing in riskier assets might choose to hold more capital, we also undertake two stage least squares and instrument the capital ratio variable using 2 year lagged values. However, the estimated co-efficient is still insignificant, suggesting that capital ratios do not have a major impact on fund performance.

We also attempt to control for fund management skills. There is considerable debate in the existing literature on whether or not managerial skill affects fund performance. Several papers (e.g. Blake et al., 1999; Ibbotson and Kaplan, 2000) have shown that most of the variation in overall investment returns depends not on the selection of individual investments, but on the asset allocation strategy (which, arguably, requires less sophisticated skills than stock-picking). Rhodes (2000) also finds little evidence of persistence in investment performance. Hence, this casts doubt on the extent to which “good” investment managers can consistently outperform “bad” managers. We proxy fund management skills using investment management expenses divided by total assets (although the assumption of a correlation between management fees and managerial skill remains a questionable one). The estimated co-efficient is positive and significant at the 5 per cent level, however this does not necessarily suggest that skilled managers have a positive impact on fund performance, over and above the higher fees they charge. Hence, as a further check, we re-estimate using investment returns net of management expenses in the dependent variable. We find the parameter estimate is no longer significant at the 10 per cent level, thus suggesting that managerial skill does not affect fund performance taking into account management fees.

Since we use post-tax data on investment returns, it is possible that some of the variation in returns is driven by cross-country differences in tax regimes. Although there exists a degree of legislated harmonization in corporate and indirect taxation across EU Member States, there is a fairly complex system of capital gains allowances and other exemptions specific to insurance firms, which may differ across countries. We attempt to control for differential tax treatments using total tax payments divided by total assets as an additional regressor, although it needs mentioning that this is an imperfect control, given that it aggregates together all taxes (including corporation and sales taxes), and does not separate out tax on investment income and capital gains which are more relevant for our purposes. The estimated co-efficient is not statistically significant, although our results need to be caveated for the above reasons.

The structure of firms’ liabilities is also important in determining the composition of assets held in the investment portfolio. Life insurance firms generally follow a broad strategy of asset-liability matching, in which the risk and duration characteristics of liabilities are matched against an equivalent composition of assets, in order to immunize the investment portfolio against market volatility. Hence, firms holding predominantly fixed nominal liabilities will tend to hold a higher proportion of bonds, whereas those whose business mix contains more variable liabilities, such as unit-linked and with-profits policies, will tend to invest more heavily in equities and real estate. Thus, the structure of liabilities held by a firm can impose significant constraints on the possibility of portfolio diversification. However, we are unable to control for the composition of firms’ liabilities due to data unavailability, and hence our results need to be caveated accordingly.

4.4 Other robustness checks

Missing investment categories

As previously discussed in section 2 above, we exclude observations with incomplete information on investment categories. We check whether our results on the QR estimate are robust to this sample selection, by replacing the excluded observations and re-estimating . We find that the broad flavor of our results is not affected, the QR estimate remains negative and statistically significant, and actually increases in magnitude in the larger sample, although the standard errors are a lot larger (see Table A2, Appendix A). We also check whether our results are robust to the assumption that missing investments in German firms are due to non-reporting of Pfandbriefe and other mortgage-backed securities. Dropping these observations and re-estimating, the results on the QR estimate are little changed. This series of tests corroborates the robustness of our results and indicates that our findings on the effects of QR regulation are not due to the exclusion of observations and assumptions on missing investment categories we have made.

Country-specific heterogeneity

Our concern here is that cross-country variation in the performance of equity markets over our estimation period might bias or decrease the efficiency of the QR parameter estimate. Thus, we model country-specific heterogeneity in the equity returns variable by undertaking Swamy Random Coefficients (RCM) estimation (parameters are assumed to be random, i.e. realizations from a probability distribution with fixed mean and variance, and distributed independently of the regressors). The restriction of homogeneity of co-efficients is rejected at the 1 per cent significance level, indicating strong evidence of country-specific heterogeneity. The QR estimate decreases slightly in magnitude, but still indicates a sizeable reduction in risk-adjusted returns of 0.9 percentage points (see Table A2, Appendix A). Overall, our results are robust to the RCM estimation, but the reduction in the size of the regulation effect needs to be taken into consideration, as it suggests that the extent to which the superior performance of investment returns in PPR countries is driven by higher weighting in equities might have been slightly underestimated.

We also investigate whether our results are being disproportionately driven by an individual country, by dropping each country from the sample in turn and re-estimating. The QR estimate remains relatively stable, although there are two interesting cases. First, excluding

France from the sample, the estimated impact of QR regulation increases by 0.8 percentage points. This is consistent with the previous discussion that, due to her relatively loose regulatory constraints, France behaves more like a PPR than a QR country. In contrast, excluding Germany from the sample leads to a decrease in the effect of regulation of 0.7 percentage points. This is consistent with the view that the tightly binding limits imposed in Germany lead to a significant cost in terms of portfolio efficiency.

Testing for structural breaks

Our main concern here is that a deterioration in market conditions after the 2001 Dotcom Bust may have had a significant impact on investment strategy and performance. Indeed, this is evident in the raw data, with most countries exhibiting lower investment returns post-2001. We conduct a Chow test for a structural break in 2001. A restriction of equality of co-efficients pre- and post-2001 is firmly rejected at the 1 per cent level, indicating strong evidence of a structural break. However, our findings on the negative impact of regulation are robust to inclusion of the break, in fact they become stronger - the effect of QR regulation increases to 1.9 (pre-2001) and to 2 (post-2001) percentage points (see Table A2, Appendix A). Thus, failure to account for this break leads to a problem of misspecification which biases downward the magnitude of the QR estimate. The driving force behind this appears to be a change in investment behaviour post-2001 in PPR countries. Comparing the data pre-and post-2001, we find that although the average weighting in equities is relatively unchanged in QR countries (increasing slightly from 18 to 19 per cent), in PPR countries there is a marked shift out of equity investment (a reduction from 38 to 22 per cent). This suggests that firms in PPR countries responded optimally to the financial market turbulence by restructuring their portfolios and shifting decisively out of equities, whereas QR firms' investment strategies were largely unresponsive. This result suggests another drawback of a prescriptive approach to regulation, in terms of the inflexibility it imposes on investment strategy.

Testing for survivorship bias

Our concern here is that the superior investment performance exhibited in PPR countries might in part be reflecting a selection bias in the following sense. It might be that firms in these countries are taking greater risks - those which are unlucky become insolvent and drop out of the sample, whereas those which are lucky survive, which has the effect of flattering the results on overall performance. To test for the presence of this effect, we exclude any firm which subsequently exits part way through the estimation period and then re-estimate. If survivorship bias exists, then in the sample which includes these poorly performing firms, the QR estimate should be smaller. We find that our results remain robust, the QR estimate does not change much and is actually slightly larger in the case which includes these “weaker” firms. However, it needs mentioning that this is a rather crude method of testing for survivorship bias - data constraints prevent us from undertaking a more sophisticated analysis.

5. Conclusions

In this paper, we investigate whether asset allocation regulations impose an efficiency cost on portfolio performance. Comparing the performance of life insurance funds in countries which impose caps on risky asset class investments with those which do not, we find evidence of a large and statistically significant impact on portfolio efficiency. Funds which are subject to quantitative restrictions experience lower risk-adjusted returns of the magnitude of around 1-2 percentage points. We formulate a panel data econometric model which explains fund Sharpe ratios as a function of the type of regulation applied and a series of control variables. Our results are robust to tests for fixed effects and country-specific heterogeneity, and a series of other robustness checks.

Our analysis informs the ongoing debate on reforms to financial regulation, borne out of the recent global crisis. Although the benefits of constraining excessive risk-taking activities have received much attention, our findings show that there are also potentially large costs. In particular, a regulatory approach which imposes explicit limits on holdings in risky asset classes can be a quite a blunt instrument, in that it can impede investment managers’ ability to exploit the benefits of portfolio diversification and thus distort portfolio choice below the efficient frontier. Indeed, it is interesting to note that these concerns have been reflected in recent reforms to EU life insurance regulation. In the new regime of prudential regulation known as Solvency II, due for implementation in January 2014, the use of quantitative restrictions in managing asset risk has been abandoned, in favour of a prudent person approach in which insurers are merely required to have adequate systems and controls in place to manage these risks.

Although our analysis focuses on insurance firms, we believe our results have broader implications for the current debate on reforms to banking regulation. In particular, a key component of the recent formulation for changes to global banking regulation, codified in the

Basel III Accords (see Basel Committee, 2010), relates to new policies aimed at bolstering regulation of banks' liquidity risk. In particular, new rules which require that banks hold a sufficient stock of "high-quality liquid assets" seem likely to skew asset portfolios towards containing a higher proportion of "safe" government bonds than under the previous regime. Our analysis indicates that a regulatory approach which emphasizes the liquidity of individual assets rather than the benefits of portfolio diversification in minimizing overall price volatility can lead to significant efficiency costs in portfolio performance.

Our results further indicate that those countries which impose the most stringent constraints on asset allocation tend to experience the largest reduction in risk-adjusted returns. This part of our analysis focuses purely on heterogeneity across countries in restrictions on equity holdings, but it is reasonable to believe that similar effects arise with other risky asset classes. For instance, it is likely that imposing stringent constraints on foreign asset holdings will prevent investment managers from exploiting the benefits of international diversification. A ban on investment in derivatives would also likely be counterproductive, in that it prevents the use of sound risk management tools in mitigating portfolio risk. But these work strands are beyond the scope of the current paper and are left for future research.

Our analysis also sheds light on other differences between QR and PPR regimes, beyond the constraints imposed on portfolio diversification. For example, there may also be costs imposed due to the inflexibility associated with QR rules. Market conditions change rapidly. Firms subject to prescriptive regulation are less able to respond quickly to such changes, compared to firms under a PPR regime which receive no more instruction than to invest prudently and hold well-diversified portfolios. We find evidence of this effect by detecting a structural break after the 2001 Dotcom Bust. Firms in PPR countries responded to the financial market turbulence by shifting decisively out of equities, whereas QR firms' investment strategies were largely unresponsive. However, a more detailed investigation of these issues is beyond the scope of the current paper and is left for future work.

Acknowledgements

We would like to thank Isaac Alfon, Peter Andrews, Maria-Jose Barbero, David Blake, E. Philip Davis, Bill Francis, Kevin James, Etienne Michelin, Mark Rhodes, Jesus Saurina, Ron Smith and seminar participants at the Bank of England, Cass, Nottingham, SOAS and Surrey for helpful comments and suggestions. Much of this paper was written whilst the authors were working at the Financial Services Authority (FSA) UK, whose support and comments (in particular those of the Solvency II policy team) are gratefully acknowledged. Rida Zaidi is currently employed by The Royal Bank of Scotland. Manuela Croci is currently employed by the National Bank of Abu Dhabi. The views contained in this paper are entirely those of the authors and do not necessarily represent the views of the FSA, or those of The Royal Bank of Scotland group (RBS) or the National Bank of Abu Dhabi (NBAD). RBS and NBAD are not responsible in any way for the content and shall have no liability to any person or entity therefore.

Appendix A

Table A1: Estimation results of main model specifications

This table summarizes the results of the pooled OLS, Random Effects (RE) and Between Groups (BG) model estimations. The dependent variable is firm-level risk-adjusted returns. Bond, Equity and Real Estate denote the respective country-level market returns (adjusted for volatility). Column (1) refers to the specification including the binary regulation dummy, and column (2) to the three tier regulation variant. Heteroscedasticity-robust standard errors are reported in brackets. *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. [a]Indicates the estimated effect of QR regulation (relative to PPR) in terms of risk-adjusted returns (p.p.), assuming a risk target of 6.5 p.p.

Explanatory variable	**Pooled OLS**		**Random Effects**		**Between Groups**	
	(1)	**(2)**	**(1)**	**(2)**	**(1)**	**(2)**
Constant	0.889*** [0.163]	0.925*** [0.163]	1.096*** [0.348]	1.161*** [0.346]	1.01*** [0.287]	1.07*** [0.287]
Size	-0.014 [0.010]	-0.016 [0.010]	-0.022 [0.024]	-0.027 [0.024]	-0.027 [0.019]	-0.029 [0.019]
Bond	0.212*** [0.020]	0.206*** [0.020]	0.215*** [0.019]	0.213*** [0.019]	0.164 [0.106]	0.172 [0.106]
Equity	0.247*** [0.022]	0.236*** [0.021]	0.233*** [0.023]	0.231*** [0.023]	0.463*** [0.090]	0.438*** [0.090]
Real estate	0.074*** [0.017]	0.053*** [0.017]	0.049*** [0.013]	0.043*** [0.013]	0.331*** [0.083]	0.263*** [0.089]
QR	-0.154*** [0.055]	-	-0.216** [0.087]	-	-0.158 [0.097]	-
R.A.R.[a]	-1.00	-	-1.40	-	-1.03	-
Weak QR	-	0.110 [0.072]	-	0.100 [0.130]	-	0.009 [0.125]
R.A.R.[a]	-	0.72	-	0.65	-	0.059
Strong QR	-	-0.231*** [0.056]	-	-0.327*** [0.085]	-	-0.243** [0.105]
R.A.R.[a]	-	-1.50	-	-2.13	-	
No. obs.	2067	2067	2067	2067	2067	2067
Specification Tests (p-values in brackets)						
Breusch-Pagan LM Test for Random Effects			181.64 [0.000]	178.34 [0.000]		
Hausman Test (Random Effects vs. Hausman-Taylor)			18.37 [0.003]			
- with France as PPR			4.34 [0.502]			

Table A2: Robustness Checks

This table summarizes the results of various robustness checks. The dependent variable is firm-level risk-adjusted returns. Bond, Equity and Real Estate denote the respective country-level market returns (adjusted for volatility). "Additional controls" compares the results of the main specification (under data limitations) (1), with that including additional control variables (2). "Missing assets" gives the results when firms with missing investment categories are included (1), and when German firms assumed to hold pfandbriefe etc. are dropped (2). "RCM" models random coefficients on the equity returns variable. "Break" models a structural break in 2001 (QR post-2001 denotes the QR estimate for the post-2001 sample, all other estimates refer to the pre-2001 sample). Heteroscedasticity-robust (except for RCM) standard errors are reported in brackets. *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. [a]Indicates the estimated effect of QR regulation (relative to PPR) in terms of risk-adjusted returns (p.p.), assuming a risk target of 6.5 p.p.

Explanatory variable	**Additional controls**		**Missing assets**		**RCM**	**Break**
	(1)	**(2)**	**(1)**	**(2)**		
Constant	1.528*** [0.486]	1.543*** [0.513]	2.575** [1.20]	0.496 [0.325]	1.074*** [0.225]	1.11*** [0.327]
Size	-0.043 [0.032]	-0.046 [0.033]	-0.086 [0.057]	0.018 [0.022]	-0.025* [0.015]	-0.023 [0.022]
Bond	0.237*** [0.020]	0.235*** [0.021]	0.266*** [0.049]	0.201*** [0.025]	0.184*** [0.020]	0.166*** [0.018]
Equity	0.269*** [0.030]	0.271*** [0.032]	0.262** [0.108]	0.339*** [0.033]	0.288*** [0.080]	0.299*** [0.046]
Real estate	0.025 [0.016]	0.022 [0.016]	0.121 [0.095]	0.035 [0.027]	0.052*** [0.018]	0.057*** [0.014]
QR	-0.375*** [0.140]	-0.384*** [0.140]	-0.797* [0.478]	-0.199** [0.099]	-0.132* [0.076]	-0.298*** [0.106]
R.A.R.[a]	-2.44	-2.50	-5.18	-1.29	-0.86	-1.94
QR post-2001 R.A.R.[a]	-	-	-	-	-	-1.88
Capital ratio	-	-0.540 [0.550]	-	-	-	-
Tax rate	-	3.151 [10.39]	-	-	-	-
Managerial skill	-	11.51** [5.629]	-	-	-	-
No. obs.	1424	1424	2714	1265	2067	2067

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